

# **Berkeley's Potential Interest and Roles in an Underground Scientific Laboratory**

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Astrophysics  
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# Topics to be Addressed in the Coming Decade

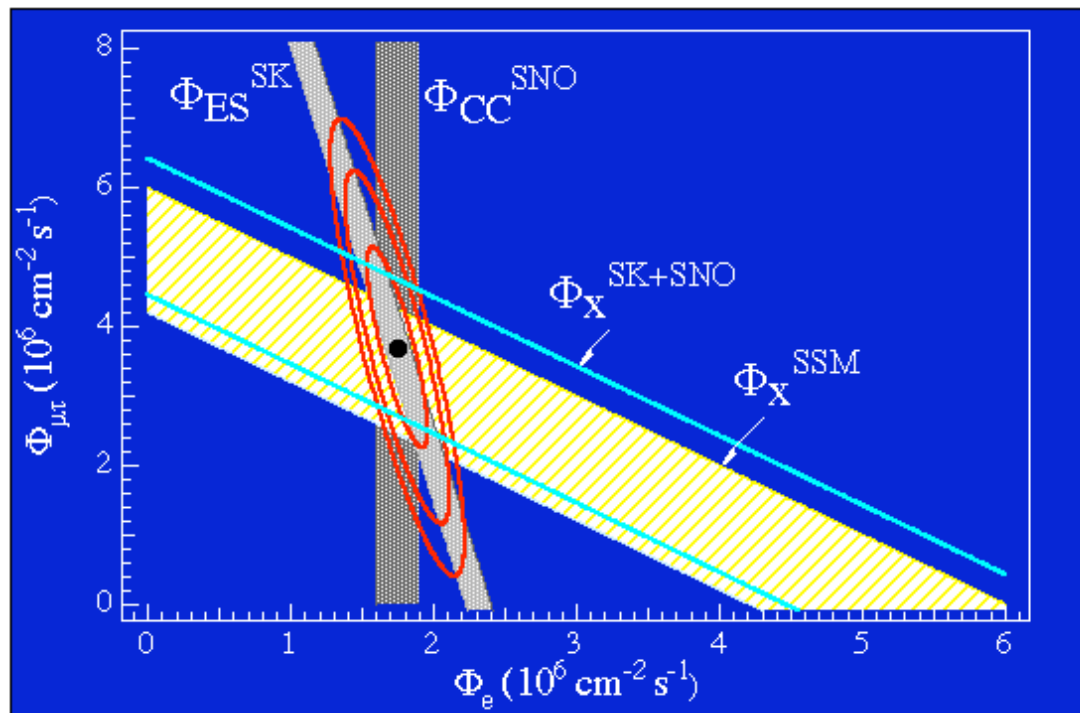
## Neutrinos and Underground Expts

- Establish Mixing parameters - MSW solutions and MNS elements
- MNS unitarity and Existence of Sterile Neutrinos
- $\theta_{13}$  & CP violation
- Neutrino Absolute Mass Scale
- Dirac or Majorana Neutrino

## Proton Decay



# Solar Neutrino Experiments



## Recent Advances:

- SNO reports flavor changing appearance

$\nu_e \rightarrow \nu_\mu \text{ or } \nu_\tau$

- SSM confirmed

## Future Experiments

Superfluid He  
High Pressure TPC  
Doped Liquid Scint.  
Mo foils + Scint.  
 $^{76}\text{Ge}$

**New Physics Beyond  
the Standard Model  
in the Lepton Sector**



# Solar Neutrino Experiments

- Most technology issues made good progress in past 5 years
- Sun now well understood  $\phi$ -source:  $\sim 1\%$ .
- Next Generation Experiments will be ready to submit major proposals in 2 to 5 years for at least 2 techniques
- Backgrounds are **the** major issues -- Cosmic rays and byproducts, deeper is better, at least 4500 mwe, and realistically  $>6000$  mwe required.
- Significant overlap with Dark Matter and  $\phi\phi\phi$



# Double Beta Decay

## Highlights

- Observing a factor of 2 increase in  $t_{1/2}$  each year
- $2-\nu$  decay may be a major background for  $0-\nu$  experiments

## Future Experiments

$^{130}\text{Te}$  Bolometer

$^{136}\text{Xe}$  TPC

Mo foils + Scint.

$^{76}\text{Ge}$

Will probe effective mass regime indicated by atmospheric and solar neutrinos



# Double Beta Decay

- Technology has made great progress in the past decade.
- Only experimental approach to Dirac/Majorana nature of neutrinos
- May be the only direct approach to neutrino masses
- Next Generation Experiment Proposals ready within 1 to 2 years
- Significant overlap with Low Energy Solar Neutrinos and Dark Matter.



# Supernovae Searches

- **Several Experiments entering or nearing prototype phases**
- **Will detect 1000s to 10,000s of events from galactic Supernova, largest can ‘see’ nearby galaxies**
- **WIPP likely site for first deployment of at least one detector**
- **Will probe supernova mechanisms, neutrino oscillations, neutrino mass scale**



# National Underground Scientific Laboratory

- **Dark Matter Searches**
- **Double Beta Decay**
- **Low Energy Solar Neutrinos**

**Require** great depth for next generation experiments, at least 4500 and realistically >6000 mwe

- **Proton Decay**
- **Supernovae Searches**

Many Common Experimental Techniques and Requirements

Some Experiments Multipurpose if Properly Situated (deep enough)



# National Underground Scientific Laboratory

- **Multipurpose World-Class Laboratory: world's deepest, Gran Sasso Model - expandable, long term**
  - **Physics**
    - Double beta decay
    - Low energy solar neutrinos
    - Supernovae searches
    - Dark matter searches
    - Proton decay
    - Long baseline
  - **Geophysics**
  - **Biophysics**
  - **Industrial applications**
  - **Significant Outreach**

**Nuclear Physics  
Long Range Plan  
High Priority**

**Extensive Nuclear  
Physics Discussion**

**Independent  
Multidisciplinary  
Committee  
Examination**

**NSF Proposal**

- **Usual peer review**



# Previous slides are from SNOWMASS, July 2001

- How have things changed since then?
  - SNO's results are  $> 5 \sigma$  for  $\nu$  transformation
  - Nobel prize for Ray for Homestake
  - KamLAND to report results soon
  - The NSF review process is advancing
    - NeSS workshop
    - NFAC Review for NAS
  - Interest & proposals from Fermi & BNL in  $\nu$ 's
  - Off-axis *ideas* in the US and developments & hardware in Japan



# Areas of Interest to Berkeley Lab at a National Underground Laboratory

- **Physics**

- **Low Energy Neutrinos**

- Building on SNO, MNS matrix elements,  $\theta_{12}$ , sterile  $\nu$ , magnetic moments, solar models, CNO  $\nu$

- Neutrino Astrophysics Group

- **SNO, KamLAND, LDRD**

- **Double Beta Decay**

- Nature of the neutrino, neutrino mass

- Nygren, NSD (at 88) for detector concepts, Norman

- **Cuore, GRETA group?**

- **Astrophysics**

- Nuclear Astrophysics Group

- AFRD

- **ECR source work**



# Areas of Interest to Berkeley Lab at a National Underground Laboratory

- **Physics**
  - **High Energy and Accelerator Neutrinos**
    - MNS matrix elements,  $\theta_{13}$ , CP violation,
      - Kam Biu, Karsten,
    - **AFRD MC collaboration, FNL experimental groups**
    - **Proton decay?**
  - **Low Background Counting, Infrastructure**
    - Infrastructure
      - Smith, Norman, McDonald, Donna
    - **LBL LBF**
  - **Project Management, Engineering, Construction**
- **Geophysics and Earth Science**
  - Long history at similar sites (Yucca Mt., WIPP, ...)
- **National Defense and Homeland Security**



# Where is the Homestake Proposal Now?



# *NeSS 2002*

A Report on the NSF Workshop on  
Neutrinos and Subterranean Science  
19-21 September 2002

Kevin Lesko  
Karsten Heeger  
Bill Carithers  
Kem Robinson  
Joe Wang



# Why was there a NeSS Workshop? What else is going on?

Two Large MRE's caught  
the attention of OMB and  
OSTP.

Both are associated with:

Neutrinos

EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20502

March 29, 2002

Dr. Bruce Alberts  
President  
National Academy of Sciences  
2101 Constitution Avenue, N.W.  
Room 215  
Washington, DC 20418

Dear Dr. Alberts:

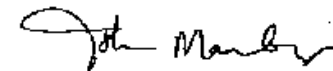
As indicated in the President's FY 2003 Budget Request for NSF under the Major Research Equipment and Facilities Construction Account, the Office of Science and Technology Policy requests that the National Research Council (NRC) review the scientific merit of IceCube, and other proposed U.S. neutrino collectors in the context of current and planned neutrino research capabilities throughout the world. The report's findings and recommendations relative to IceCube would inform a decision whether to initiate its construction in FY 2004.

In addition, I request that this review assess the merits of neutrino detectors associated with deep underground research laboratories and large volume detectors, like IceCube. Specifically, the NRC should address the unique capabilities of each class of new experiments and any possible scientific redundancy between these two types of facilities. The review should also include:

- The identification of the major science problems that could be addressed with 1-km<sup>3</sup> class neutrino observatories,
- The identification of the major science problems that could be addressed with a deep underground science laboratory neutrino detector.
- An assessment of the scientific importance of these problems and the extent to which they can be addressed with existing, soon to be completed, or planned facilities around the world.

I am requesting that such a review be carried out under the sponsorship of NSF and completed by September 1, 2002.

Sincerely,



John H. Marburger, III  
Director



# THE NATIONAL ACADEMIES

Division of Sciences  
Division of Life Sciences  
Division of Earth and Planetary Sciences  
National Research Council

Advisers to the President on Science, Engineering, and Medicine

April 8, 2002

The Honorable John H. Marburger, III  
Director, Office of Science and Technology Policy  
Executive Office of the President  
Eisenhower Executive Office Building, Room 424  
Washington, DC 20502

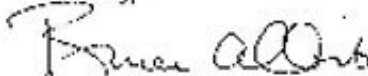
Dear Jack:

I am writing in response to your letter of March 29 requesting a review of proposed U.S. neutrino collectors and the nature and importance of the science problems that such facilities could address.

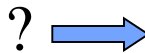
I have asked our Board on Physics and Astronomy to form a committee under the National Research Council to undertake this study. The committee will be charged to complete an approved Research Council report in accordance with your request within 6 months of conclusion of an agreement with the National Science Foundation for financial support of this work.

Thank you for this expression of confidence in the NRC's ability to provide useful and timely advice on scientific matters of importance to the nation.

Sincerely,



Bruce Alberts  
Chairman  
National Research Council



## From Barry's Presentation

### NFAC Membership

Barry C. Barish, California Institute of Technology, Chair  
Daniel S. Akerib, Case Western Reserve University  
Steven R. Elliott, Los Alamos National Laboratory  
Patrick D. Gallagher, National Institute of Standards and Technology  
Robert E. Lanou, Jr., Brown University  
Peter Meszaros, Pennsylvania State University  
Hidoshi Murayama, University of California, Berkeley  
Angela V. Olinto, University of Chicago  
Rene A. Ong, University of California, Los Angeles  
R. G. Hamish Robertson, University of Washington  
Nicholas P. Samios, Brookhaven National Laboratory  
John P. Schiffer, Argonne National Laboratory  
Frank J. Sciulli, Columbia University  
Michael S. Turner, University of Chicago

#### NRC Staff

Donald C. Shapero, Director  
Joel Parriott, Study Director



## Charge to NFAC

The Neutrino Facilities Assessment Committee will review and assess the scientific merit of IceCube and other proposed U.S. neutrino detectors—neutrino detectors associated with deep underground research laboratories and large volume detectors, such as IceCube—in the context of current and planned neutrino research capabilities throughout the world. Specifically, the study will address the unique capabilities of each class of new experiments and any possible redundancy between these two types of facilities. The review will also include: (1) the identification of the major science problems that could be addressed with cubic-kilometer-class neutrino observatories; (2) the identification of the major science problems that could be addressed with a deep underground science laboratory neutrino detector; and, (3) an assessment of the scientific importance of these problems and the extent to which they can be addressed with existing, soon to be completed, or planned facilities around the world.



# Meetings & Schedule

**First meeting:**

June 24-25, 2002

National Research Council –Washington, DC

Begin data gathering

**Second meeting**

July 25-26, 2002

O'Hare Hilton Chicago, IL

Complete data gathering;

**Third meeting**

Sept 30 - Oct 1, 2002

Caltech Pasadena, CA

Complete draft report.

**Draft report sent for review**

October, 2002

**Public release of report**

November, 2002



# NFAC Committee Process

- Our final face-to-face meeting will be at Caltech Sept 30 – Oct 1, when we plan to formulate our report.
- That meeting is timed to take maximum advantage of NeSS 2002, and yet meet our deadline for the report.
  -  *Members of NFAC are participating. Talk to them!*
  -  *We are soliciting short “Executive Summaries” from each working group immediately following this meeting and we intend to make good use of them at our final meeting.*
- The NFAC study is on a very fast track! We are working very hard and intend to make a thoughtful report that is responsive to our charge.



# NFAC – Important Considerations

- **NFAC is asked to address to what extent the science “can be addressed with existing, soon to be completed, or planned facilities around the world.”**

*✍ We have had presentations at our meetings to try to understand the global context of the proposed U.S. initiatives.*

- **NFAC is asked to assess “the unique capabilities of each class of new experiments and any possible redundancy between these two types of facilities.”**

- **Our study and report is being developed with the full consideration of the recommendations in several recent reports:**

*✍ The NRC Report “Connecting Quarks and the Cosmos: Eleven Science Questions for the New Century,”*

*✍ The NSAC Long Range Report for Nuclear Physics*

*✍ The HEPAP Long Range Report for High Energy Physics*



# Conclusions

- **NFAC and NeSS 2002 are obviously very closely related**
- **We welcome, encourage and look forward to the best possible inputs from this exciting workshop**

**GOOD LUCK !**

MRE's, the Review Process and NSF's Role in Large Science Projects appears to be evolving. NeSS and the NFAC committee are part of, and indicators of, that evolution



# (Conveniently) NSF found they had \$ in FY03 Budget for a Neutrino Workshop

## AGENDA

International Workshop on Neutrinos and Subterranean Science

NeSS 02

Washington, DC

Thursday, September 19, 2002

8:30 Opening Remarks-Joseph Bordogna (**Deputy Director**)

8:45 The NSF View of NeSS 2002-Joe Dehmer (**Head of Physics + Astronomy**)

9:00 Theoretical perspectives on fundamental physics underground-John Ellis

9:40 Theoretical perspectives on astrophysics from underground-Michael Turner

10:20 Break

10:50 Experimental Perspectives on Underground Science - **Stuart Freedman**

11:30 Perspectives on Underground Geo-Science and Engineering-Tullis Onstott

12:10 Report on NRC Study-Barry Barish

12:30 Lunch Break

14:00 **Parallel Sessions I**

15:00 -15:30 Coffee Break

19:00 - 20:30 Reception





Friday, September 20, 2002

8:30 Parallel Sessions II

10:30-11 Coffee Break

13:30 Plenary Session

13:30 US High Energy Neutrino Experiments in Ice-(Halzen)

14:15 Other High Energy Neutrino Experiments -including  
ANTARES, NESTOR, NEMO, Baikal (Fernandez)

15:00-15:30 Coffee Break

15:30 Subterranean Science-(Haxton)

16:00 Non-US Subterranean Plans-(Kajita)

16:50 US San Jacinto-(Sobel)

17:10 US Carlsbad Underground National Laboratory-(Haines)

17:30 US Subterranean Facility at Homestake-(Haxton)

17:50 Adjourn

Saturday, September 21, 2002

8:00 Parallel Sessions III - Working Group Windups

9:00 Executive Summaries of the Working Groups (15 minutes each)

10:30 Coffee Break (30 minutes)

11:00 Executive Summaries of the Working Groups (continued)

11:30 Future Directions-John Bahcall

12:15 Concluding Remarks-Tom Gaisser



## WORKING GROUPS:

- ➔ 1) Double beta-decay  
Giorgio Gratta  
Wick Haxton (Cuore)
- 2) Proton decay  
Hank Sobel  
Jogesh Pati (Hitoshi Murayama)
- ➔ 3) Neutrino Oscillations and Mass, and CP violation  
Michael Shaevitz  
Vernon Barger (Karsten Heeger)
- 4) Dark matter  
Richard Gaitskell  
Richard Arnowitt
- ➔ 5) Solar Neutrinos and Stellar Nuclear Processes  
Michael Wiescher  
Tom Bowles (SNO, KamLAND)  
M.C.Gonzalez-Garcia (Karsten Heeger, Mario Cromaz, Lee Schroeder)
- ➔ 6) Astrophysical and Cosmological Neutrinos  
David Nygren  
Eli Waxman
- 7) Geology, Geo-Biology, and Geo Engineering Geomicrobiology  
Tullis Onstott
- 7a) Geochemistry - Petrology Steve Kesler
- 7b) Geohydrology & Engineering Brian McPherson
- ➔ 7c) Geophysics Bill Roggenthen (Wang)
- 7d) Geomechanics & Engineering Herb Wang
- ➔ 8) National Security Kem Robinson  
Frank Hartmann (Lesko, Wang)
- 9) Education & Outreach Susan Millar



# *NeSS 2002*

200 to 250+ attendees

- ~Equal attendance in physics sections
- All major US expts, proposals & facilities represented
- NSF and DOE in attendance
- University and Labs both well represented

WRT Neutrino Properties and  $\square$  Oscillations

- significant advances in the field since the last such meeting (SNO results) focused the discussion on future experiments



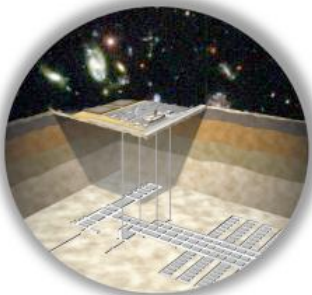
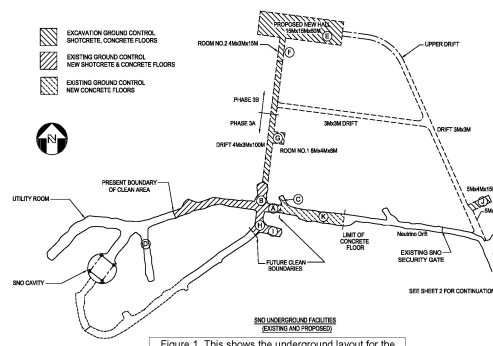
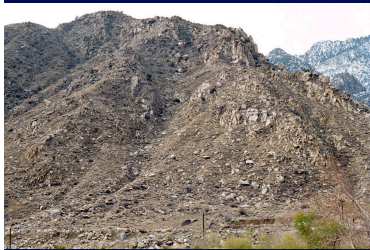
# NeSS 2002

RPM Outline  
26 September 2002

Introduction and Overview	Lesko	✓
Underground Facilities - status	Lesko	
Accelerator Oscillations + CP violation	Heeger	
Double Beta Decay	Heeger	
Solar Neutrinos	Lesko	
Astronomical Neutrinos	Carithers	
National Security Applications	Robinson	
Geophysics	Wang	



# Homestake Mine



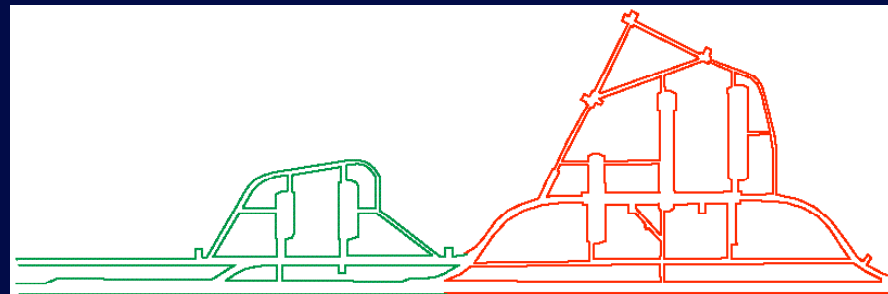
- Homestake - MRE Proposal (paper and committee review passed)
  - despite several deadlines having passed Homestake is still being pumped (support from Barrick ~\$100k/mo)
  - Barrick maintaining staff of ~35 people u/g
  - Barrick replaced hoist cables and significant PM on hoist
  - Cl expt asked to remove components, Pb from Majorana removed

- Proposal prepared...waiting...

- C\$35M for new room (16m x 60m L) PICASSO DM expt
- New Surface building planned

Domenici produced \$3M budget “to do science” (read “buy experiments”) for WIPP, beyond the 100kg of  $^{136}\text{Xe}$

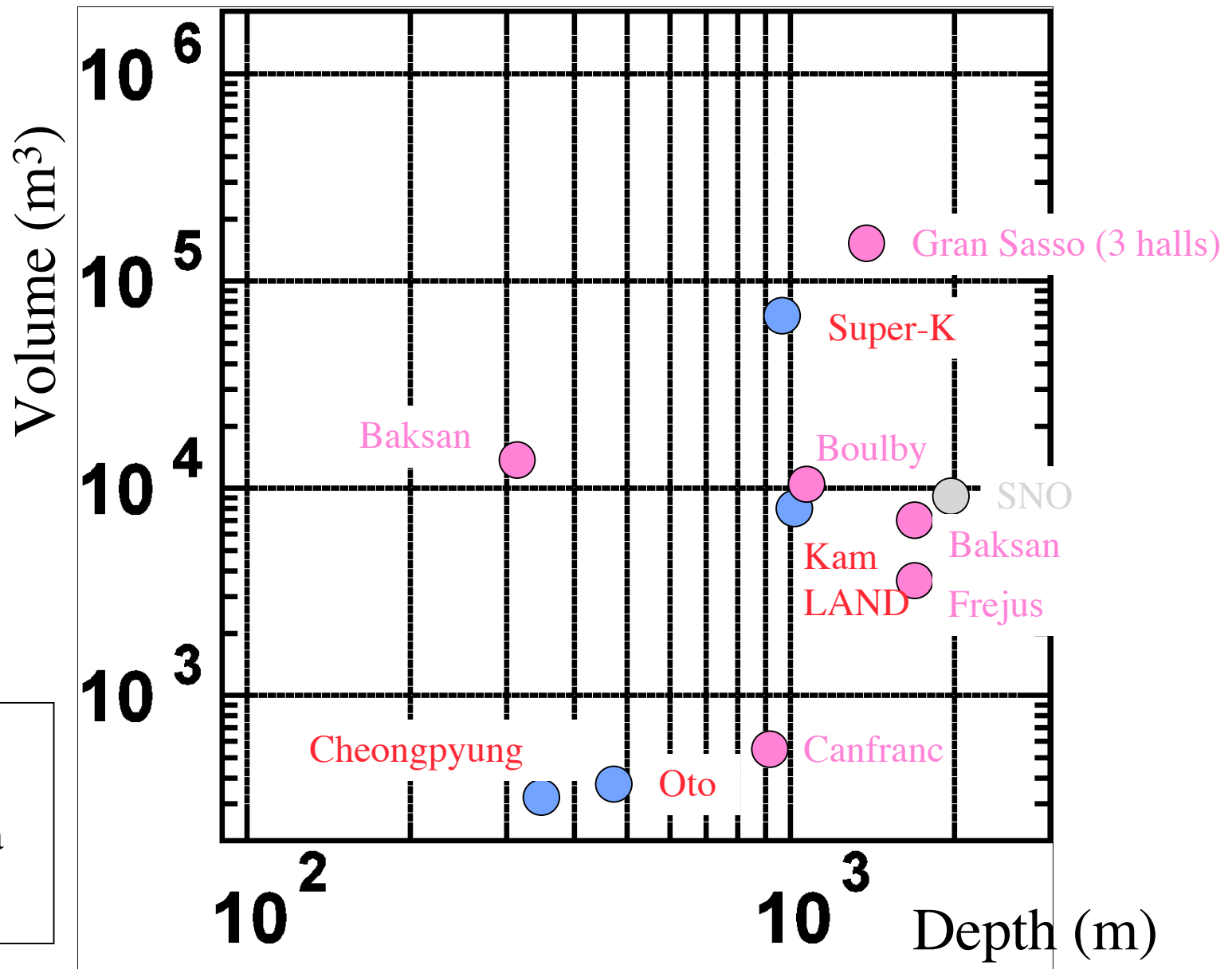
## Proposal for 2 new smaller halls, otherwise “full up”





## Summary of the present non-US underground labs.

Kajita

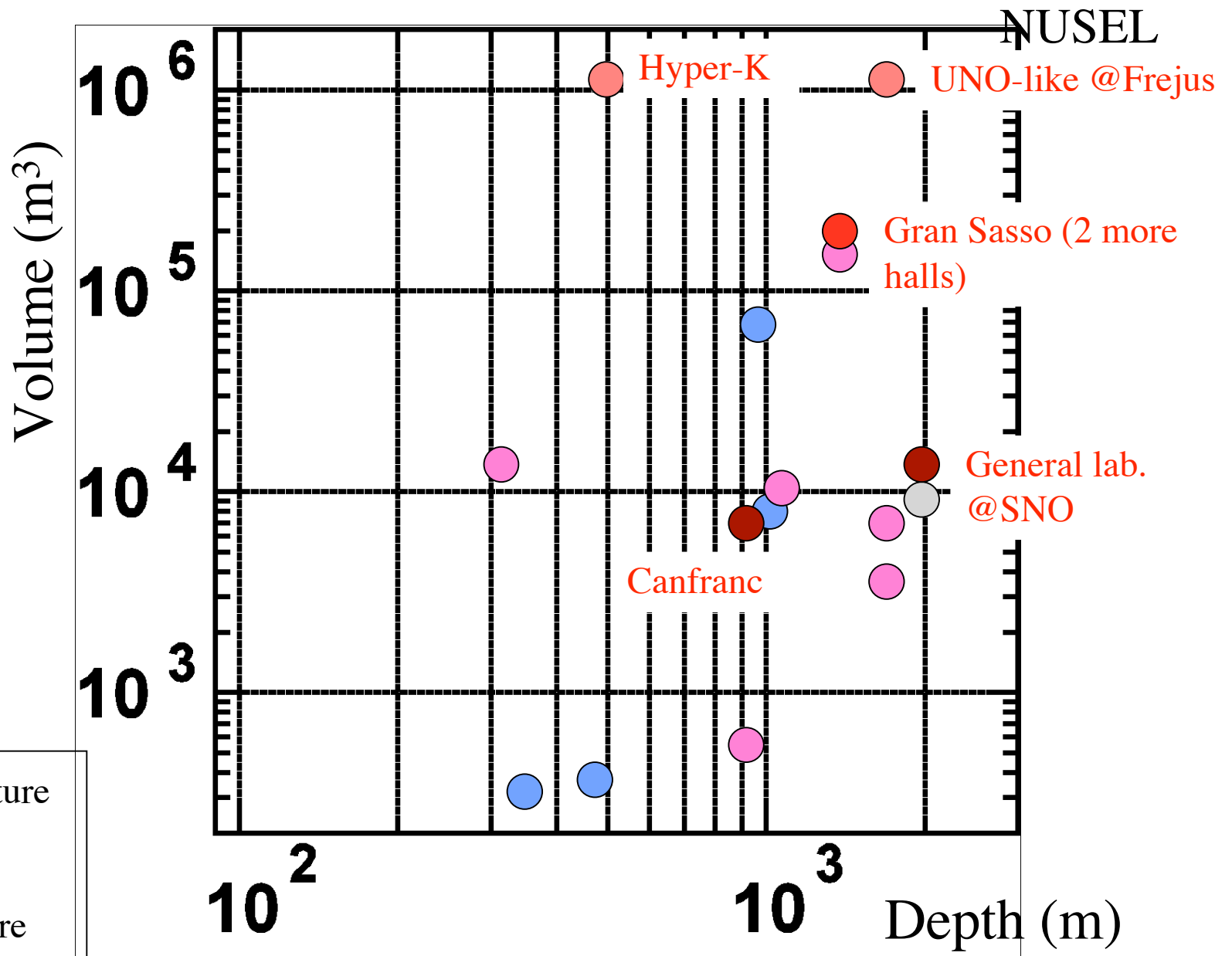




Possible future non-US underground labs.



Kajita





## Shallow Labs:

Small Expts

High Thresholds

Prototyping

Manufacturing

Supernovae

Security

High Energy

## Intermediate Labs:

Medium-Large Scale Expts

Lower Thresholds

UNO (multipurpose)

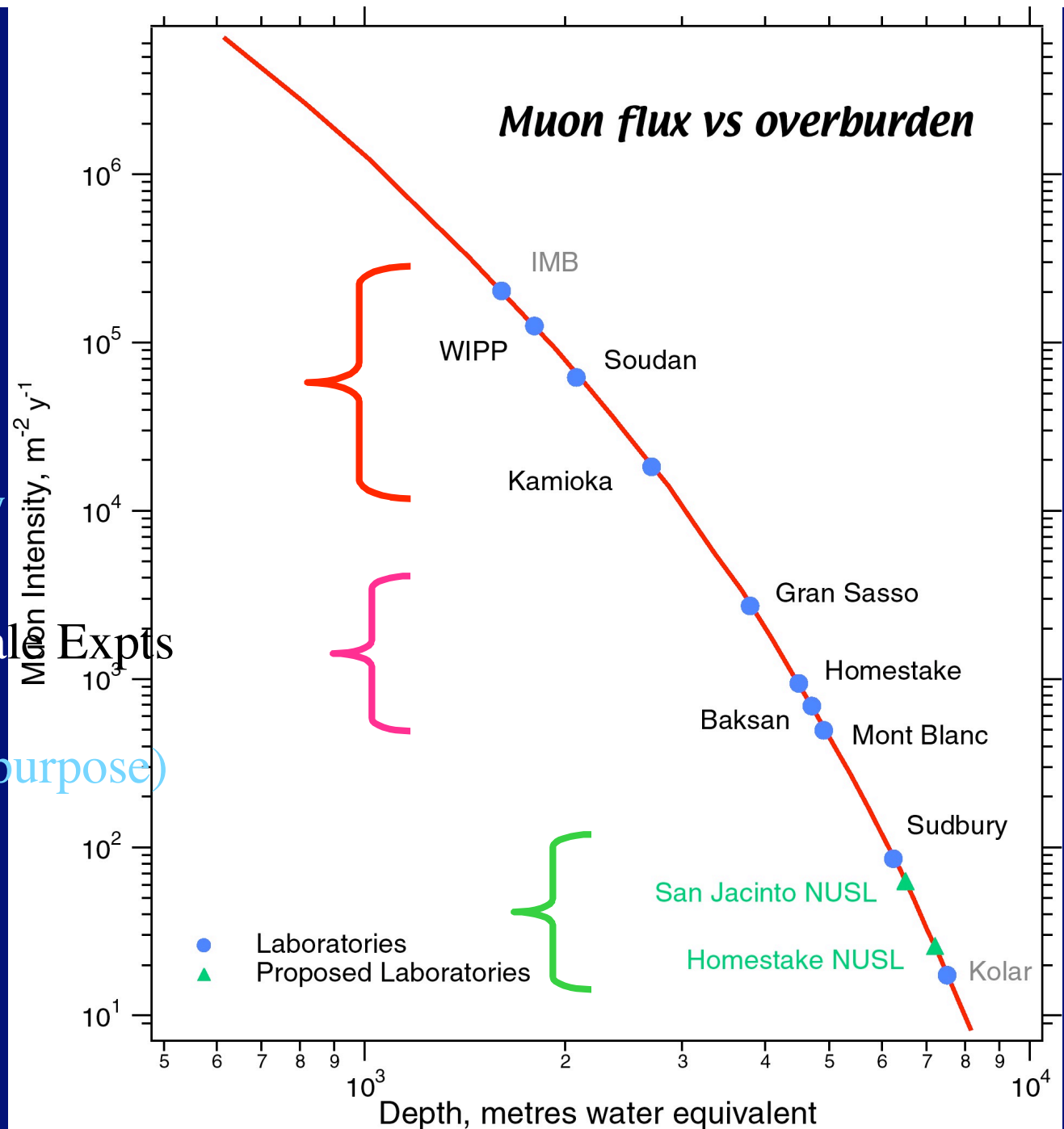
## Deep Labs:

Large Scale Expts

Lowest Thresholds

DM, Solar  $\square$

some DBD





# What Next?

- **Berkeley well situated to play a large (leading DOE) role in NUSEL.**
  - **They need what we have to offer**
    - **PM**
    - **Engineering, Accelerators**
    - **Scientific Leadership for Several Experiments**
    - **Low Background Counting**
    - **Geophysics**
    - **Experience**
  - **There is concern by some of the NUSL PI's that someone like LBL might muscle in**
    - **We should**
    - **Lead the DOE charge to this site**